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PROBLEMS ENCOUNTERED IN DEVELOPING AND MAINTAINING A FIELD SYSTEM TRAINING PROGRAM

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"REQUIREMENTS FOR A FIELD SYSTEM TRAINING PROGRAM"

Lawrence T. Alexander

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In this symposium we would like to discuss some of the experiences we have had in installing and maintaining the System Training Program for the Aircraft Control and Warning Radar Net of the Air Defense Command. We believe that the human factors problems we have encountered in the five years since the training program was first installed are representative of those to be found in all similar systems.

Although all of the participants in this symposium have been involved primarily with the research effort associated with the System Training Program, all of us have had considerable experience in the field, "on the firing line" as it were, applying the conceptual training model, conferring with military personnel, and adapting training aids and procedures to operations problems as they arise. Each of the speakers will discuss a different aspect of the problem of system training. I will describe the Air Control and Warning net, the AC&W system of the Air Defense Command, and discuss the training requirements of such a system. Dr. Rogers will discuss simulation technology and training inputs. Dr. Jordan will talk about knowledge of results and how it is utilized. Dr. Jensen will discuss the military cultural environment and its implications for training. Dr. Ford will indicate how the principles and techniques we have learned may be applied to training man-machine systems of the future.

The AC&W system is a complex man-machine information processing system. Its ultimate mission is to defend the United States against air attack. The goal of the training program is to increase the proficiency of the human components of the system in accomplishing this mission.

For those of you who may not be familiar with the system, let me tell you briefly how it works by describing a typical element, the Direction Center. The Direction Center receives information in many forms. Although its primary input is radar data, it also receives flight plan information, weather information, and intelligence information. It uses this information to identify all aircraft which appear in the air space for which it is responsible. Identification is usually accomplished by comparing the position, speed, direction, and altitude of an aircraft, obtained from radar data, with similar information obtained from flight plan data. If it is not possible to correlate flight plan and radar information, an interceptor aircraft is scrambled and directed to the location of the unknown aircraft so that positive visual identification may be made. In order to accomplish the air defense mission it is necessary for a Direction Center to cooperate with adjacent stations by passing relevant information back and forth and to keep the command personnel informed of its actions.

The early version of the AC&W net was called the Manual Air Defense System because all phases of its operations were carried on primarily by humans. Because of the ever increasing density of air traffic over the continental United States and because of the development of new weapons systems which reduce the amount of available warning time for defense, the AC&W net has been automated. The present air defense system, SAGE, has at its core a high speed digital computer. In the present system the computer handles most of the routine data processing functions. Humans monitor and assist the computer and make the more important decisions regarding threat evaluation and tactical action.

The system which I have been describing to you is a large scale, complex, information processing, man-machine system. It is large scale and complex in the sense that it has a task which has many dimensions. The task cannot be performed by a single individual or by a single machine, but requires the coordinated actions of many men and machines. The field within which the people in the system operate is so large that no one of them or no group can have access to or assimilate all the information which is available. In most cases no individual can appreciate all the ramifications of any action he may take. Consequently, there must be fractionation of the decision-making processes and some over-all supervision and coordination of the decisions made.

The commodity with which the system deals is information. The system operates by coding, storing, decoding, and reorganizing information for many different purposes. The essential pre-requisite for adequate system functioning is the rapid, correct manipulation and transmission of information among the various system components.

What are the training needs for a complex, man-machine, information processing system such as this? The first requirement is to develop component skills of individual operators. The Air Training Command maintains schools in which operators learn about air defense operating procedures, learn how the computer works, and how to operate the various consoles and telephone networks by which they communicate with the computer and with each other.

A second requirement is a period of on-the-job training at a SAGE Direction Center in which the trainee begins to apply what he has learned in school and begins to operate as an integral part of his crew. A third requirements is system training and it is this latter requirement with which we are primarily concerned here.

System training seeks to develop the skills by which individual crew members work together smoothly as an efficient team. It augments individual component skills by developing such interactive skills as pacing, load balancing, error checking, and information filtering. It provides the opportunity for system personnel to practice together in dealing with realistic operational threat situations.

The computerized system environment introduces unique training problems to those of us who have been concerned with the human factors requirements of systems. Let me state briefly what some of these problem areas are. The speakers who follow will discuss them in more detail.

Stimulus Inputs. A system training exercise must accomplish two purposes: First, it must provide the crew with the opportunity to experience and practice defending against various kinds of potential air threat situations; second, it must impose load on the information processing and decision making operations of the system. The simulated air picture is one of the primary stimulus agencies in a system training exercise for accomplishing these purposes.

Motivation and Morale. One of the main characteristics of the SAGE system is the psychological isolation of the operators. Almost all interpersonal relations must be conducted by a telephone or via the computer. Added to this is the fact that in order to perform adequately at the speeds required, it is

necessary to divide the various tasks into small units. These two factors combine to prevent the individual operator from gaining an over-all picture of how the system operates and, more importantly, how the functions he performs contribute to the system mission. Consequently, it is difficult for crew personnel to maintain at a high level the motivation required to perform the complex operations involved.

Another problem in the area of motivation and morale involves the usurpation by the computer of many of the functions which have previously been considered the particular province of the human. There is a general feeling among all system personnel that they are not in touch with the real environment and can only get information concerning this environment by means of a complex gadget which they do not completely understand and which, to some extent, they regard with some degree of fear. In addition to this, there is the feeling of loss of control over the environment. Most of the decisions they make must be implemented through the computer which is set up to amplify, and in some cases modify, the results of these decisions.

Knowledge of Results. System training, like all other forms of training, requires the provision of adequate knowledge of results. The requirements for fed back information differ for various people in the system and for the team as a whole. Since these requirements change as a function of the threat situation and the developing proficiency of the crew, the problem of providing adequate knowledge of results resolves itself into a problem of selecting appropriate information at the right time. Too much information may be as bad as none at all. In providing knowledge of results, the trainer must determine answers to questions such as the following: How much information should be provided? When should it be provided? How should it be collected and displayed? How should it relate to the needs of the trainees as these change over time?

Utilization of Knowledge of Results. In System Training Program exercises, trainees are given information about the simulated air threat with which the system was faced and a description of how the system performed in meeting the threat. This information is provided to the crew for debriefing. In the debriefing session the crew attempts to identify areas of inefficient operation and to produce solutions to the problems thus identified. These solutions, which usually consist of modified operating procedures, are then tried out in a later exercise and may be adopted as command-wide standard operating procedure.

Personnel Selection and Turnover. The System Training Program is not immediately concerned with problems of personnel selection. These are handled in accordance with Air Force policy. The system must operate with the personnel with which it is provided, and the training program must do the same. However, of vital concern are the training problems introduced by personnel turnover. One of the goals of training is to produce a well-integrated, smoothly functioning team in which the individual team members work well together. Constant turnover of personnel mitigates against this and reduces the efficiency of the system as a whole. One of the requirements of a system training program is to develop techniques which will reduce the deleterious effects of personnel turnover.

These, briefly, are some of the system training problem areas we have identified. Now let me describe how a system training exercise is conducted so that

you might have a greater appreciation of how the training techniques which the following speakers will discuss fit in. All system training exercises are conducted at field operational sites. The exercises usually last about two hours exclusive of the debriefing. Team personnel are exercised in their operating positions using all the equipment which they would normally use in real operations. The threat situation is developed in consultation with Air Force operations and training officers and is presented to the crew by means of normal operational input equipment. Although the inputs to the system simulate a real air situation, it is difficult for system personnel to distinguish between the simulated and real inputs. Except for the fact that system personnel know that the air situation is part of a training exercise, they are required to perform exactly as they would in the case of a real air threat. System training exercises have been designed for functional units of the SAGE system of various sizes from the single Direction Center to the entire nationwide network operating simultaneously.

During the exercise performance data are collected for the provision of knowledge of results. Since all of the inputs are designed beforehand, the trainer has complete knowledge and control of the stimulus. After the exercise, crew personnel meet together for a debriefing session in which the exercise is discussed.

"THE APPROPRIATE CONTRIBUTION OF SIMULATION TECHNIQUES TO SYSTEM TRAINING"

Miles S. Rogers

To the outsider, one of the most impressive aspects of system training is the extent to which the environment of the system has been simulated. We not only simulate a coordinated dynamic air picture, we also simulate information concerning this air picture from the Federal Aviation Agency, adjacent military units, higher headquarters, and intelligence sources. Furthermore, we simulate air bases, fighters in the air, and even weather, at times. All in all, we try to simulate all sources of information which might reasonably affect the performance of the unit being trained. Often one of the first questions asked is: "Why do you simulate? Why not use 'live' inputs and 'live' aircraft?" Our experience has yielded the following answers:

1. The first reason for simulation is in order to practice rare events. The Air Defense System Training Program is intended to help the Air Defense System prepare to defeat the airborne aspects of an attack on this country. We hope this event will never occur. If it does occur, the system's performance will have to be perfect the first time or it will be too late to use the real event as a basis for training. Therefore, the only way the system can practice is with a simulated air attack. Although this reason may seem unique to the Defense System, it is fair to say that any system may be required to handle situations which occur infrequently in real experience. By simulation, the system can practice dealing with the rare events and thereby learn to handle them.

2. Another reason for simulation is its relatively low cost. In order to train a system it is necessary to repeat the situation to be learned many times. If the task to be learned is launching a missile, each real launching usually costs one missile and repetition for training can become expensive. On the other hand, although the cost of a missile simulator might be several times as much as the missile, the simulator's cost can be pro-rated over a large number of simulated launchings. Thus, the overall cost of training by simulation can be considerably less than training with the "real thing." In STP we use films, magnetic tapes and scripts in place of live aircraft. We are, therefore, able to repeat the same simulated attack as often as desired for training purposes at far less than the cost of duplicating the training by real aircraft.

3. A third reason for simulation is the fact that the input to the system being trained can be controlled by the training specialist. He can vary a simulated input from exercise to exercise according to his training strategy. In order for learning to occur, a problem situation must be created. The crew being trained must find itself unable to perform as well as it desires in some situation. For example, the air surveillance section of an air defense unit can be forced to perform in such a situation by simply increasing the amount of penetrating air traffic. It is relatively easy to produce such heavy traffic loads in STP exercises whereas variable can hardly be controlled at all in real life.

   This principle of controlling the input to produce a learning situation can be extended with simulation techniques to parts of the system not in contact with the outside world. Thus selective training can be provided for subsystems while they are operating in the context of the total system. One example of this in the Air Defense System would be training exercises

designed to emphasize training of the Identification Section. This section has the task of correctly associating tracks representing aircraft in the air and air movements data which are the intended flight paths provided by the aircraft operators. To place the Identification Section in a problem situation, the training specialist must increase the number of tracks to be correlated and increase the number of items of air movements data. This can be accomplished in STP by simply providing the Air Surveillance Section with scripts so that it can process perfectly an STP exercise with a lot of penetrating traffic. Since penetrating traffic must be correlated with air movements data, the Identification Section is now faced with a task as hard as it can ever be expected to perform. If the section cannot immediately adjust to the load it now has reason for learning and an opportunity to observe its progress independently from that of the Air Surveillance Section. As you can tell from the amount of time I have spent on this point, control of the input is perhaps the most important reason for simulation in a training program.

4. Another reason for simulation is that when simulation techniques are used, a very precise knowledge of the input to the system is available to the training specialist. This precise knowledge of the input is fundamental to his ability to provide accurate knowledge of results. The importance of accurate knowledge of results will be discussed by another speaker.

Given these purposes for simulating, the next question is: "How realistic must this simulation be?" In our experience we have provided simulated inputs which have ranged from extremely crude scripts to a very precise duplication of the real thing. Prior to our experience with the Air Defense System, the answer was: "Simulation should be adequate for training." This answer generated the following corollary: "The more realistic, the more adequate." This particular point of view seems to be characteristic of the trainees and their supervisors during the early stages of crew development where any slight deviation from realism will be used as an excuse for avoiding real problems and real issues which the crew must solve before it can develop. On the other hand, our training specialists in the field have come to the position that each case of simulation must be considered on its own merits and in relation to what its training objectives are. Therefore, the question must be restated as: "How is this proposed method of simulation going to help train whom to do what?" It has been our experience in the laboratory that this latter approach is correct and the corollary mentioned above is not necessarily so. A general rule of thumb we have used is, "The simulation should be realistic enough so that the people involved in the system being trained are required to perform similar functions, similar responses, and undergo mutual interactions similar to those required in real operations." Like all rules, this one has its exceptions, particularly where more realism is required for motivation or evaluation. The exact degree of realism still remains a professional judgment. In other words, "realism" is not the answer, or really even the question. The problem is, "What is best to accomplish the needed training?" This problem can best be solved by the wise judgment of an experienced professional training specialist.

Several general principles regarding simulation have arisen from our experience. Among these are:

1. Before undertaking to provide simulation adequate for training, it is necessary to acquire a thorough knowledge of the system to be trained. We

must know who does what before we can decide which simulation method is best. Preferably, the system should be studied in operation. If this is not possible, its plans must be intensively analyzed, their consequences predicted as far as possible, and, if time is available, a "breadboard" mock-up of the system should be built and placed in operation in a laboratory before the final simulation method, materials, etc., are produced.

2. An accurate knowledge of the events being simulated is fundamental to any written or pictorial materials describing these events. In system training, we have found it desirable to provide the personnel responsible for collecting data for knowledge of results with charts showing the "true" air picture every five minutes. This precise knowledge of the input is designed to help these people determine what, if anything, is going wrong at any given time. Inaccuracies in such printed descriptions create erroneous knowledge of results. These errors are used by the trainees to avoid being trained just as lack of realism is used in early stages of crew development.

3. When agencies interacting with the system by means of people are being simulated, the people must be simulated accurately. In our case, interceptor pilots, Air Route Traffic Control Center personnel, air base personnel, etc., must be accurately simulated because person-to-person interaction, especially the kind of task oriented pacing that takes place over telephone and/or radio communications, is always critical to the performance of the member of the system being trained. Improper simulation of these kinds of interactions can lead to avoidance of training but more importantly, it can lead to harmful effects such as the use of improper radio-telephone procedure, habitual failure to request important information because the simulator volunteers it, and failure to check information because the simulator is always correct. Finally, improper simulation of personal interactions can most readily lead to a poor attitude toward training such as, "So what, it's only a game!"

4. On the other hand, it is possible to carry accurate simulation too far. In our case, it was found rather easy to develop an elaborate table of kill probabilities. These probabilities could be made to take account of all sorts of possible events in the conduct of an intercept after the pilot had been instructed to splash the hostile target. The resulting simulation tables could be calculated to three decimal points. It is obvious that this degree of accuracy is quite irrelevant if, in the course of a training mission, any one intercept director has less than ten intercepts to be evaluated. In other words, by virtue of other aspects of the training program, the three decimal places and a good deal of the rest of the sophistication of the kill probability tables was wasted since it did not make any difference to anyone being trained. In fact, since it so often resulted in an intercept director being told that an otherwise perfect intercept failed due to the kill probability, the resulting decline in motivation has challenged the whole notion of a kill probability table. Professional judgment has yielded a simplified simulation where the conduct of the intercept is evaluated up to the firing pass and a few numbers written on another aid are used as a crude kill probability table to account for the final outcome. Thus, the rest of the system has a realistic outcome fed back into it and the intercept directors are not penalized for events beyond their control.

5. Flexibility is another key principle of simulation, if simulation is to contribute appropriately to a training program. Just as training needs will vary from day to day, crew to crew, subsystem to subsystem, the simulation techniques must be permitted to co-vary or they will fail to achieve their goal of training. This approach leads to a proposition which is true in general, but, of course, has some exceptions, to wit: "If the simulation task is repetitious and requires precision, try to get a machine to do it; in all other cases a person is preferable because his procedures can be changed overnight." A strict application of this principle will often lead to the apparently absurd situation where there are more people on the simulation team than on the operations unit being trained. This anomaly, however, appears to be one of those "facts of life" which might as well be accepted. We have found that premature automation of simulation in an attempt to reduce the number of simulation personnel has been one of the prime sources of difficulty in our training program.

In summary, let me state the principle facts we have learned concerning the contribution of simulation techniques to a training program:

1. Simulation is needed in order to provide a system with practice in handling events which occur infrequently during operations.

2. It is relatively inexpensive because its initial cost can be pro-rated over a number of repetitions.

3. Most important of all, simulation provides the training specialist with control of the input to the system so that he can easily implement a training strategy of his choosing.

4. The question of realism is really irrelevant. The proper criterion of simulation is a professional judgment of how effectively it enables a training goal to be achieved by a specific system, subsystem, or component.

5. Before any simulation is attempted it is necessary to know thoroughly the system to be trained.

6. Inaccurate simulation aids, materials, and techniques usually defeat the purpose of training by providing the crew with an excuse for avoiding its own problems.

7. Too sophisticated simulation can distract a crew from facing real issues. Instead they may spend their time questioning the facts underlying the simulation. Professional judgment is required to set the proper level of sophistication for training purposes.

8. Finally, simulation must be flexible if it is to contribute to a training program.

"MAN-MACHINE TRAINING TECHNIQUES - TORING, FEEDBACK, AND DEBRIEFING"

Nehemiah Jordan

As you must have noticed, we have developed a private language for talking about this program. Three words that we use quite frequently are: TORing, feedback, and debriefing. These are names we have given to training techniques which play a central role in the program. The techniques will be explained, described, and then discussed briefly.

TOR, T, O, R, - is an abbreviation for "Training Operations Report." This phase denotes the specific information gathered by observers on the crew's performance during the training exercise.

Why gather such information?

Knowledge of results or, to phrase it more accurately, knowledge of the discrepancy between what was actually accomplished and what should have been accomplished, is, in the opinion of most training experts, a necessary condition for effective training. Most training programs are so set up that such knowledge is fed back to the trainee as soon as possible. Production line operators need similar information in order to be able to evaluate their performance rationally to know how to improve upon it. Unfortunately, in complex man-machine systems, the operator often finds it difficult, if not impossible, to get accurate objective knowledge on the results of his performance. In addition, with the exception of major breakdowns or serious errors which stand out for all to see, knowledge of the total system performance is also at best quite global and non-specific. Hence, information which can serve as the basis upon which the crew can rationally decide what steps it should take to improve its performance is generally lacking or inadequate. The TOR attempts to supply the necessary information.

How do we TOR, and what is TORed?

This varies with the system. As you already know, we have had experience in training two types of systems: The manual air defense system and SAGE. The former, the manual system, is the familiar radar site which is manned by small crews of twelve to fifteen persons who function in close interaction. The latter, the SAGE system, is radically different. It is highly computerized and automatized and is manned by crews of up to 100 persons. In addition, since the SAGE crew is located in several large rooms, much of the interaction between the members is mediated by the computer and/or telephones. Therefore, although the basic principles underlying TORing are the same for both these systems, we have found it necessary to introduce many changes in specifics when we began to train the SAGE system.

Here too, as in almost every other aspect of the training program, experience hammered home a simple basic fact. No matter how correct training principles and the training design generated by them are, they cannot be applied simply to a specific situation. A gap will always exist between the principles and practice. It is the job of the professionals in the field who implement the program to fill this gap. In other words, the professional in the field does not passively implement the training program but creatively applies it to fit the specific conditions of the crews to be trained in light of the problems confronting them. He is continuously called upon to make judgments based upon his professional skills in analysis and prognosis. This point may seem obvious and you may wonder why mention it at all, let alone stress it. Nevertheless it is quite surprising to find that all too frequently, this phase of "application" is overlooked either completely or in part.

To return to how we TORed. TORing is rather simple in the manual system. The TOR team which collects information on the crew's performance consists of two or three persons, generally an experienced non-commissioned officer with one or more airmen who are not necessarily experienced. They sit in full view of the plotting board which serves as the central memory for the system. By observing it the TOR team can see how the crew processed each inputted flight and when each step took place. In addition, the TOR team has special aids showing the flight paths of the planned critical flights that the site has to process in a known manner to achieve an efficient air defense. At the end of the exercise the TOR team has a record of how the crew processed the critical flights and relates this processing to the actual simulated input.

In SAGE a major difference in TORing is the fact that information gathering on crew performance is automatized, i.e., the computer maintains a record of the crew actions which it can print out at the end of the exercise. This information is detailed and quite long since, commensurate with the increased size of the crew and increased efficiency of the processing system, the number of critical flights processed by the SAGE sector is quite large. The information available from the print-outs is consequently much too detailed for immediate feedback to the crew. Too much information feedback gives indigestion.

The TOR team for SAGE comprises senior experienced personnel who are recognized by all as being experts in the system. Their job is two-fold. During the exercise they sit among the crew and act as trouble shooters, noting down that which they consider important to feed back to the crew. After the exercise they can also examine the printouts and cull from them objective information which they consider important. The information that is gathered and selected by the TOR team is presented to the crew.

Because of lack of time it is impossible to go into details on the difficulties which we ran into in setting up the SAGE program despite our explicit planning to anticipate the new environment. Suffice it to say that: (a) The original planning left something to be desired, and (b) because both the training personnel and the crews came to SAGE from the manual system, they carried over with them numerous habitual ways of doing things that were inappropriate to SAGE. We had quite a lot of trouble at the outset. This is being ironed out with experience.

Feedback, as we use it, refers to the technique whereby knowledge of results is imparted to the crew. One principle underlies feedback -- it has to be an objective account of factual performance and, by implication, it must be accurate. According to this view, the feedback of inaccurate information is worse than no formal presentation of knowledge of results. The nature of the information fed back does much to determine whether the subsequent debriefing will be a good one, that is, will be task and problem solving oriented, or will be a setting where a lot of steam is let off to no consequence.

Why this stress on "objectivity" and "factuality"?

In our culture one person's telling another that he is performing poorly is often perceived as personal criticism. This evokes defensive behavior which hinders the individuals concerned from facing reality and generates instead a quest for scapegoats, rationalizations, and often counter attacks. On the other hand, our culture has a very healthy respect for facts with which one

is not supposed to argue. If the crew is convinced that they are confronted with facts, it becomes difficult for them to avoid facing the issue and it becomes easier for the debriefing leader to counter-act defensive behavior which is apt to occur.

Formal organized TORing and feedback are but steps that lead to debriefing. In fact, under certain conditions they are not necessary since crews can themselves present the necessary information. The debriefing is the setting and the vehicle wherein and whereby the most effective crew training takes place. As such, debriefing could be a subject for a symposium as long as this one in its own right. Within the limitations of the present symposium the most I can hope for is to present a bare skeleton outline of what should be richly discussed in itself.

A "good" debriefing was just characterized as being task and problem solving oriented. In the discussion, the individual crew members should not be evaluated, but system performance and crew procedures should. Proposed procedures aimed at improving system performance should not be imposed by fiat of even a large majority. The debriefing leader should see to it that all individuals affected by a given problem should have their say in discussing it. The solution to be reached should be one that all involved are <u>willing</u> to try out.

Debriefing is rather simple in the manual system. Immediately after the exercise, the crew meets in a special room or area set aside for the purpose. The TOR is presented to them in a straightforward manner. Instances of poor performance are identified and a discussion is developed to determine what caused the poor performance and what steps can be taken to see that it doesn't happen again. The crew members are also encouraged to raise additional problems concerning the system operations which they want discussed. One member of the crew keeps a "debriefing log" in which all the problems discussed and the decisions taken concerning them are recorded. At the end of the meeting the log is read back to the crew.

We have met with many difficulties in implementing debriefings in the SAGE system and, at present, we are still struggling with the matter. Some of the main causes for this are: the large size of the SAGE crew; the lack of adequate debriefing space; the complexity of SAGE performance which makes it difficult to give knowledge of results that is relevant to all the crew members; and a marked decrease in the interdependence of the crew members because of the computer's mediation of much of their interaction. These difficulties seem to be technical and have not led us to doubt the basic utility of debriefing as a training technique. However, we now know that debriefing is much more difficult to apply to some man-machine systems than to others, especially when these systems are designed without training considerations being taken into account.

The pay-offs of a program with "good" debriefings are many. Below are a list of six of the more obvious ones:

1. <u>The quality of the solutions found to problems confronting the crew is superior</u>.

   In these matters, more brains representing a greater area of collective experience, is better than less brains. The fact that all those who will be affected by the proposed solution are given a chance to have their say concerning it, at least guarantees that it will not contain the usual number of "bugs" that

stem from unique contingent conditions which experts have no way of knowing. For instance, the absence of a prescribed communication channel cannot be known by the expert but is certainly known by the operator who mans the position. He will, therefore, see to it that no proposed solution is based on this non-existing telephone channel.

2. The quality of solution implemention is superior. This for two reasons. Men understand a procedure far better if they discuss and analyze it than when it is handed to them in a written memorandum no matter how precisely phrased. What men understand better they can implement better. In addition, men are more highly motivated to implement a procedure which was formulated with their active participation.

3. Early rectification of many problems before they become critical. This occurs both overtly and covertly. Because of the atmosphere in a "good" debriefing, men often raise problems which in more formal circumstances they would hesitate to mention. And this, in turn, can play the role of the stitch in time which saves nine. In addition, the debriefing often has, willy-nilly, a "therapeutic effect". The mere fact of discussing operational problems with other crew members also tends to use a clinical term, to "work through" problems in interpersonal relations that exist among the crew members before overt conflicts develop. And, last but not least, a procedural solution reached by discussion will frequently include in a sort of piggy-back manner, solutions to various other minor problems that are irritating the crew.

4. A series of debriefings is an excellent educative setting where the crew members get to know a lot about the system in general. In discussions which pertain to proposal and justification of system operating procedures a lot of information concerning the overall nature of the system is elicited. Since the crew members are involved in the discussion, they tend to remember the information. Increased knowledge of a system by the operators of a system is always a worthwhile thing.

5. The overall morale of the crew improves. A group of men who successfully work together and solve problems together get to know each other relatively intimately. This results in a development of an esprit de corp, an increase in group cohesiveness. It follows that the overall morale will rise. Concomitant with this development, there is an increasing compatibility of individual crew member goals and the system goals, that is, the product that the system was designed to process becomes important, per se, to the crew both as a group and as individuals.

6. And finally, there emerges: A trained efficient problem solving group well prepared to cope with unexpected contingencies. What we have had to say here on TORing, feedback, and debriefing has been a result of our experience in implementing the System Training Program and in experimentation both in a laboratory and under field conditions.

"PROBLEMS OF CONDUCTING SYSTEM TRAINING IN A MILITARY CULTURE"

Barry T. Jensen

Preceding papers have indicated the nature of the System Training Program (STP), problems relative to simulation, and some of the major concepts related to the use of knowledge of results in debriefings. The present paper will discuss three of the major problems arising from the conduct of a program of this nature in the military. The system training program was designed to be operated by personnel of the Air Defense Command after orientation by the staff at SDC. Originally the SDC representative at each military headquarters advised the Commander and performed a liaison function. At present the field training team is much more active in the conduct of the STP.

Some of the problems we found are unique to STP while others will be found wherever there are conditions similar to those with which we work. Major problem areas which might be mentioned include those due to (1) introducing new procedures into a culture, (2) utilizing military personnel as training personnel, and (3) aspects of the military culture antagonistic to new training procedures. I will present these in that order.

As an example of problems arising from introducing new training procedures which conflict with goals and activities already present, let us discuss the debriefing aspect of the system training program. The debriefing, as we know it, with an entire crew participating in group problem solving, is foreign to military culture in many respects. Many, particularly the lower echelon officers who became the debriefing leaders, perceived the debriefing situation as an abrogation of responsibility--a situation in which the responsible officer relinquished his leadership function to persons of lower rank. STP does NOT ask the responsible officer to step aside only to utilize resources of the entire crew. However, this erroneous perception created special problems for the training personnel.

In addition, officers willing to take the special kind of leadership role often could not do so because of personal considerations or other demands upon their time which led to conflict of interest. In order to institute the most effective debriefings, the part of STP most at variance with the military culture, it was necessary that certain aspects of the military culture become altered.

Frequently institutions attempt to force a change by the issuance of directives. While regulations and directives are necessary to describe changes and to establish permission to adopt new procedures, they are not sufficient. Even when the directed person is willing, compliance to a regulation may be impossible if other conditions are not conducive to the changes. As Lewin has indicated, one cannot change one aspect of a culture without bringing about concurrent changes in related aspects.

We find that adoption of debriefing proceeds best when two general conditions exist:

1. First, visible evidence of command support must promote good STP. Whenever the Commanding Officer desires something, military personnel attempt to comply. This is the place for directives indicating what should be accomplished. But beyond this we need other evidence of support. Active and continuing interest in the program seem to be accompanied by interest and activity by operating personnel.

2. Second, the organization of station activities must permit compliance. This, in a sense, requires a modification of the culture of the organization. Often debriefings are degraded by other activities which compete for time. For instance, a schedule of exercises near the end of a shift causes conflict between cleanup duties or chow time on the one hand and debriefings on the other. Other tasks interfere with STP; for example, a coincident live mission may cause cancellation of all or part of the training mission--most often the debriefing suffers as it is under the control of the local officer, particularly the debriefing leader who determines its length and its content.

The point I wish to make here is that when personnel perceive a specific aspect of a program or the entire special program such as STP as in conflict with the culture or with the on-going activities, the program usually is degraded. We find some of the best debriefing practices at installations where the training person finds a commander who is receptive to this aspect of the program. Activities are modified to support it. In these places debriefings are held in spaces especially set aside for them with plenty of time allowed free of operational duties.

Another aspect c promoting desired debriefing behavior is, of course, the training of the leader. This training must deal with his attitudes, his perceptions of the program, and his skill. He must come to see that the debriefing is a tool for fulfilling his responsibilities to improve performance of his crew. Once he sees the task in this way, becomes convinced of command support, and has time to do a good job, the training task becomes much more simple.

The second problem area relates to utilizing military personnel as trainers. By way of introduction I will discuss the adequacy of SOP's as means of regulating performance. Throughout the military, Standard Operating Procedures are formulated for the purpose of implementing directives. These SOP's attempt to prescribe the ways to process information or to execute other tasks. We find that different procedures often become effected whenever the Standard Operating Procedure is not adequate for local implementation, when the local personnel are unable or unwilling to execute them, or when the SOP is not understood. When the SOP is worded explicitly and stated in terms of actual operations, less formulation of special local procedures occurs. For example, individuals adjust to overload in a variety of ways such as combining categories, filtering, and reassigning priorities to tasks. Unless the permissible adjustments are made known and the contingent conditions for their implementation are specified, each person will filter or combine on the basis of his own perception of the task. People also take short-cuts in task performance; unless these are known to others, system performance may break down because each one is, in effect, working by his own rules. As indicated in an earlier paper, debriefings provide an opportunity for these local procedures to be formulated and for an exchange of information about personal operating procedures. In spite of this opportunity, we find conflicts resulting from unexpected behavior, omissions, or non-congruence between behaviors of different persons.

The preceding paragraph has implications for the conduct of a training program. As Dr. Rogers mentioned, in STP some of the simulation is effected through automation but men do much of it. Furthermore, in STP the training personnel process input and performance data. Thus, in addition to the system being trained

(called the operating system), we have the system doing the training (called the training system). The same problems of obtaining conformance to regulations found in the operating system are present in the training system.

The SOP's of the training system must be at least as detailed and as carefully formulated as those for the operating system. True, some areas of training require flexibility and simulator response to the developing situation. However, other tasks cannot permit this. When machines make the routine inputs, the problem of exactness lies in computer programming. But when people must handle the inputs or data collection, unique personal operating procedures cannot be allowed except in very minor matters which don't make any difference in the timing or the nature of the input.

In short, when a training program is being planned, every bit as much attention should be given to the procedures of the personnel in the training system as to the procedures of the operating system, or to the mechanics of simulation. Essential aspects of this part of the program include specification of desired inputs, determination of allowable deviations, formulation of training SOP's, training of the training crew, and monitoring of its work.

The third problem arises from the fact that certain aspects of the military culture are antagonistic to the training program, be it STP or some other. One of the prime sources of difficulty lies in the turnover of personnel in the services. In some radar crews 50 per cent of the members will have been replaced within a year. We probably should consider a crew, not as a team of specific men working together in a co-ordinated fashion, but as an organization with a slowly changing culture of its own.

When turnover occurs the new man does not know those unique procedures of the crew to which he is assigned. The replacement may be just out of basic training and thus relatively naive, or he may have transferred from another station bringing with him a culture somewhat alien to that which he now contacts. In either case, each transfer requires a period of orientation and initiation.

When a number of crewmen work together for a time a great deal of "social learning" occurs. As a result, a stable crew may have less need for formal SOP's than a newly formed crew or one which suffers frequent insult to its integrity. The crewmen learn each other's idiosyncracies and can accommodate or compensate. In a number of field and laboratory situations we have noticed a progression in crew development from concern with one's own procedures through an interest in understanding other men's actions, to trying to modify the others' procedures and then to the point where the men help each other by sharing the load. Presumably with constant turnover, the higher levels of performance would not be attained.

We had noticed that operating crews in the field seldom exceeded a certain level of performance, regardless of the length of the training period. On the other hand, when men were assigned to our simulation laboratory which duplicated a radar station, they learned to work as a crew and functioned at fairly high levels of performance after only a few weeks of training. We believed that one cause of the disparity lies in the differences in turnover. Consequently, a series of laboratory studies, utilizing an analogous task, was instituted to examine this hypothesis, and to explore the factors contributing to the phenomenon while trying out training procedures which might counteract the effects of turnover should they be identified.

In the first experiment, members of a crew trained together so that all members possessed equal experience. Persons experienced on another crew then systematically replaced original crew members. The performance improvement curve flattened out when compared to the performance of a crew not turned over.

In a second experiment, crews composed of members with a range of experience were replaced by green or untrained people. In this case we found a decrement in performance.

Further analysis of the data with respect to the system employed pinpointed some of the causes. "Greenness" or inexperience _per se_ was confounded with position on the crew. In this system some pairs of men worked face to face and communication between them was limited; these men did not pace one another. Men in another group of positions communicated over the telephone and in each pair one person paced the other by passing information. The bulk of the degrading effect of turnover was observed in those cases in which communication was by telephone, with one person pacing the other.

Other effects were observed with increase in the proportion of men replaced. In the debriefings, evidence of group cohesiveness was seen. Apparently introduction of only one man to this crew of seven did not affect the cohesion. But when three or more members of the crew were replaced, cohesiveness seemed to deteriorate and sub-groupings occurred--there seemed to be a breakdown into new versus old men with respect to advocacy of procedures.

Several suggestions for dealing with this matter of turnover come to mind. The most obvious would be reduction of turnover. One method might be the organization of crews of men who entered training at the same time, trained together, and transferred or discharged as a group. This has been attempted in some of the services, I understand.

A commander could minimize transfer among crews on his station--it might be better for a crew to be shorthanded than to get a temporary replacement from another crew. When replacements are necessary they might be assigned at first to jobs having less effect upon the work of others.

Designing training programs specifically to counteract the effects of turnover also seems to be a rather obvious solution. Frequently we have seen the effectiveness of STP in bringing "green" men up to levels of performance which permit them to function well as crew members. One training procedure tried in the turnover experiments mentioned above consisted of supplying positional problem-oriented feedback. That is, in addition to giving data regarding total performance to the crew, the new man was supplied with information relative to the difficulties he appeared to be having. This change in feedback procedures led to marked improvement.

I have discussed three problems of conducting system training in a military culture. I submit that they will be with us for some time. On the other hand, I believe that these difficulties need not necessarily weaken a training program.

"THE TRAINING PROBLEMS OF FUTURE SYSTEMS"

John D. Ford, Jr.

Let me first review the model of the system training program to see what are its probable strengths and weaknesses. This model was developed for a manual data processing system. Next, let me review some of the lessons we have learned in its initial application to a semi-automated data processing system, namely, SAGE. Then, I will discuss some of the problems which confront humans in the SAGE environment. Finally, I will suggest a strategy for developing training for the problems of future systems.

You will recall that the STP model consists of basically four parts. First, there is the simulation of inputs and portions of the environment. Second, there is the system operation in the context of the simulated inputs. Third, performance results relating to the effectiveness of the system and certain other specific kinds of performance are reported to personnel in the system. Finally, there is the debriefing where several or all persons in the system meet to discuss the results, identify problems, and devise solutions.

What are the strengths and weaknesses of the model? First, let us examine three of its major assumptions. The first assumption is that many major training problems exist in and therefore should be remedied in a system context. This has at least two advantages. First, to the extent that the behavioral interactions are a part of the training problem it is important to devise solutions which take these interactions into account. This might be referred to as training in a system context. Second, it can be shown that changes in operational procedures or equipment in one part of a system often require changes in other parts of the system. This is conceptually similar to the concept of change discussed earlier by Dr. Jensen. The obvious disadvantages are that to crank up a system or a portion of a system is both very expensive and runs the risk of loss of control of the training situation.

A second assumption in this model is that the information reported in the feedback emphasizes task relevant behaviors. Hence, problems of motivation and individual needs, which are important in man-machine systems, arise indirectly in this kind of a training context.

A third assumption is that this is a problem solving model and more specifically a group problem solving model. Implicit in this is an emphasis on the responsibility of individuals in a group to recognize problems and to contribute to the solution of these problems. This is an advantage to the extent that it insures the problems which are identified are the actual problems which the members of the system have encountered. Also, where there is a necessity for individual commitment to action, a group problem solving model seems to have some superiority in this respect. An obvious disadvantage is that it may run contrary to the norms of the culture in which the system is set. Specifically, the norms of a culture may be such that an individual does not admit or recognize problems or that he does not take the responsibility for these problems but rather waits for word from a higher level.

One way to test the generality of a training model is to evaluate its effectiveness in the setting of a somewhat different type of data processing system. We are beginning to accummulate some experience in this respect as we evaluate the application of this model or variations of it in the SAGE system. You may recall that the SAGE system is a semi-automatic ground environment system which has as its center a high-speed digital computer. Operators can extract data, make decisions, and instruct the computer via manual interventions by means of

associated consoles during the real time operation of data processing steps. It is reasonable to assume that the SAGE system is similar in many respects to future high speed data processing systems. While it is still too early for any very thorough going evaluation of either this training model as applied to SAGE or of the full range of training problems encountered by crews in a SAGE operation, I believe we have enough experience to make a few preliminary statements along this line.

First, it is now recognized as highly desirable to allow a shake-down period for the equipment, computer programs, and the various operational procedures which are required to run a system as complex as SAGE. I think this is analogous to the debugging or deghosting phase which applies to any complicated piece of equipment in its early research and development stages. The initiation of training programs with the expectation of solid training outcomes during this shake-down period is probably unrealistic. This is not to say that certain training or simulation procedures cannot be used as part of the shakedown. In fact, the system training simulation program has been used as a major shakedown vehicle. Any system which undergoes changes can benefit from such a simulated shakedown vehicle.

Second, when the system training model is carried forward into a semi-automatic data processing system, the scope and complexity of the training problems become very large. The problems of training the training system become intensified. The number of persons required as simulators and observers increases greatly. The computer programming effort for the development of data retrieval and analysis programs for training purposes becomes a major activity. With this comes the long lead times required for programming and equipment modification to support the training program.

This leads directly into a third observation--namely, that there develops a rigidity and complexity in the automatic storage and data processing component of the training system. Training problems change as system proficiency changes. There is a problem of providing enough adaptability or flexibility in the training program to provide the kinds of training which are needed at a particular time or point in the development of a system. We are only now beginning to learn how to put this kind of adaptability into a complex training program, and it is not at all clear yet that enough capability for change or adaptability can be built into a semi-automated training program to justify the resources and time required to develop this.

And a final observation is that it looks as though there is a hierarchy of importance of training problems in a data processing system and that this hierarchy changes as proficiency of the crew increases. From actual observation, both in the manual and SAGE systems, a change in hierarchy of training problems like this seems to occur. This is a change from problems of working with equipment in one's own position to problems of procedures and co-ordination among various parts of a system.

Now, so far I have tried to contrast or compare some of the characteristics of a system training model with the problems of making it work and with the kinds of training problems it would meet in a semi-automated data processing system. We are beginning to accummulate some observational data which is derived from a slightly different point of view with respect to problems of humans in systems. This is based upon actual experience in operating in most of the positions in a

SAGE Direction Center and in intensive operation of a particular position in the weapons section in a system context. Based upon this, we have identified six problem areas faced by humans in this kind of a data processing system. These areas are: (1) Individual positional skills; (2) Behavioral interactions with other humans in the system; (3) Awareness of effects of actions on efficiency of system; (4) Motivation for task or goals of the system; (5) Complex decision making in an automated data processing environment; and (6) Isolation and social motivation.

Individual positional skills refer generally to the skills required to communicate with the computer. These skills include those necessary to extract and interpret information and those required to insert into the computer instructions or actions which the operator decides are appropriate in his data processing task. Typically, a computer data processing system reads out, prints out, or displays information to operators in coded or symbol form, hence the operator must learn to interpret the codes or symbols very rapidly. There is a further problem in some systems of many classes of information with the possibility of ambiguity, crowding, overprinting, etc. This is particularly true if information is displayed on a situation or geographic type display. Usually, instructions are inserted manually into the computer by means of sequences of steps or switch actions. These must be learned, and there is considerable motor skill in performing them correctly both in sequency and timing with respect to computer cycling or frame time. These skills might be thought of conceptually as the basic skills of a particular position, because without them the operator is unable to communicate with the computer, which is the central locus of data processing in such a system.

Behavioral interactions with other humans in the system can ramify into a great many types of problems. However, I will confine myself to the verbal communications which are elicited or required by operators as they perform their data processing task. One aspect of this problem is the sheer number of communications which can converge upon certain positions in a data processing system. In fact certain key positions in a system can become so overloaded communication wise that it is impossible for one individual to respond physically to all of the communication attempts. In certain of these positions the operator is provided with an assistant, referred to as a technician, whose responsibilities are to assist in some of the data extraction and manual action insertions to the computer and to assist in handling the communication load both to and from the position. It turns out that this is a mixed blessing, because a new set of communication problems develop, namely, the meshing of communications between the two operators. It has been observed that with inappropriate signals and inappropriate timing each can interfere with the work of the other while attempting to make legitimate communications to that person. I have seen a substantial amount of positional degradation introduced because these two operators would communicate with each other at times that interfered with some other task, or information would be passed to the other with the assumption that he had received it when in fact he was preoccupied with another task and did not receive the information.

Awareness of effects of actions on the efficiency of the system might be regarded as the key objective of system training. To illustrate, I will give here only one example which could be multiplied many times. In SAGE the Weapons Assignment Officer must have at his disposal a number of kinds of information to make effective decisions concerning commitment of weapons to targets. This information must be timely, accurate, and complete. Some of this information is inserted

via manual card punching in a room which is physically separated and organizationally remote from the Weapons Section of the center. The operators who must insert this information have many other classes of information to insert and which are extremely important for various other tasks or functions in the system. I think it is too much to depend upon administrative directives or a policing system to see that the crucial information is provided in an accurate and timely manner. When an operator has several jobs to do at once he must choose among them, that is, he will have a subjective priority scheme from which he will select those that he ought to do first, second, etc. Often this means some things don't get done because of over crowding. What is important here is that the operator's priority hierarchy conform as nearly as possible to some hierarchy of importance which will render maximum system effectiveness. One of the ways to do this is give him data pertaining to the consequences of his actions or lack of actions upon certain crucial performance outputs. Because these decisions have to be made in relation to a large number of items and through changing circumstances, it does not seem practical to depend solely upon rules or supervisory surveillance to accomplish this kind of performance.

I believe motivation regarding the task or goals of the system will become an increasingly important problem in more automated data processing systems. We cannot rely solely upon a written or formal statement of the task or goal of the system to serve as a motivating device. First, because of increasing specialization and compartmentalization in these systems, it becomes difficult for an individual to place his particular task or job in a context which makes sense to him. Second, many of the data processing jobs are not the most exciting, and when performed day in and day out and month in and month out become in fact, routine and boring. I guess we don't have to belabor the point that a highly skilled operator who regards his task as senseless can contribute as much or greater degradation to system efficiency than will an unskilled or new man or the malfunctioning of equipment within the system.

Complex decision making in a data processing environment is, I think, a very fertile territory for research. Since these complex decisions are often the most crucial outputs of data processing systems, we need to determine what characteristics of a data processing environment permit the most effective decision making on the part of humans.

I have saved isolation and social motivation until last, because I think the last shall become first. I believe that in future systems these problems will assume major proportions. It has already been mentioned that automated systems tend to compartmentalize operators into very small units. Combined with this is the degree of attention and lack of mobility which is required to operate effectively in terms of inputs and outputs with a computer. In addition there may be a sense of lack of control of the environment or, in other words, that the computer is running things. All of these factors will make social motivation a more important problem in future systems. I believe we do not realize the extent to which we depend upon the reactions of others to derive a sense of social validation for what we are doing or the appropriateness of this task or that goal. Also, there seem to be certain minimum conditions necessary for social interaction. When these conditions are not met, humans will engage in behaviors or adjustments to restore some minimum set of conditions for this interaction. Much of the so called non-task oriented behavior in formal organizations can be subsumed under this type of phenomenon.

Well, having outlined some of the kinds of problems which I can see, what can be done about them? Some of these problems can be remedied by system design. This includes human engineering and system design which takes into account the full behavioral interactions in system operation. Interestingly enough, when most qualified supervisors talk about skilled operators in the SAGE System, the common thread of skills appears to be those which involve getting around the limitations of the equipment or the computer program. To the extent that some of these limitations can be changed these problems can be remedied by systems redesign.

When it comes to training, I believe the feeling is growing that no one training procedure alone is adequate for the highly complex and changing training needs of data processing systems. Training should be designed to accomplish specific training purposes. For some purposes training should be small scale, that is, not tieing up major equipment or large portions of a system. If part of the problem involves behavioral interactions among parts of a system or among individuals in the system, then this behavioral interaction should be included as part of the training environment or training system. This suggests that in some cases the system training model can be applied to a smaller portion of the system, perhaps the interactions among three or four operators or at least a small portion of a system.

On the other hand there are training problems which require the participation of a large portion of the system and the development of an extensive training system, simulation, automated data collection, etc. There appears to be an inverse relationship between scope of system to be trained and frequency of training periods. Adaptability to changing training problems is facilitated with the medium or small-scale training program. As system integration becomes a more important problem in the development of a particular system, large scale training programs will become more important.

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System Development Corporation,
Santa Monica, California
PROBLEMS ENCOUNTERED IN DEVELOPING
AND MAINTAINING A FIELD SYSTEM
TRAINING PROGRAM.
Scientific rept., SP-107, by
L. T. Alexander, J. D. Ford, Jr.,
B. T. Jensen, N. Jordan, M. S. Rogers.
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Compiles papers presented by each
author at a symposium of the 1959
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Society at the University of
California, Los Angeles. Papers
were concerned respectively with
1) requirements for a field system
training program; 2) the appropriate
contribution of simulation techniques
to system training; 3) man-machine
training techniques: Training Operations
Report (TOR) feedback and debriefing;
4) problems of conducting system training
in a military culture; and 5) the training
problems of future systems.

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